



February 24, 1994

*rust*  
FROM: R. G. Finkle/H. Gertje  
Headquarters Materials Laboratory, 7365  
Phone: 586-7838 SCAN 321-7838

TO: M. M. Lwin/W. Whitney  
Bridge and Structures, 7340

RE: SR-167, OL-1511A, CS 1766  
15th ST. SW. to S. Grady Way  
Bridges #167/121 through #167/128  
Interim Supplemental Foundation Recommendations

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As requested, we are providing supplemental recommendations for drilled shafts and P-y curve data for widening the eight referenced bridges. Original recommendations for this project were provided by Terra Associates in their December, 1992 geotechnical report. This report contains specific recommendations for pile foundations, but provided only a general discussion for drilled shafts. The Bridge Office requested that we provide more specific methods for drilled shafts, along with P-y curve data in a format compatible with COM 624. Our shaft design methods were discussed with you and ABKJ Incorporated at a meeting on December 15, 1993. The design data for Bridges #121 through #124 were transmitted to ABKJ on December 17, 1993. A discussion of our shaft design methods and recommendations is provided below.

We used the subsurface data presented in Terra Associates' (Terra) report, along with WSDOT data for the original bridge designs contained in our files to evaluate critical design parameters. The predominant issue governing the design of all eight bridges is the potential for soil liquefaction during seismic conditions, immediately beneath the embankments. This issue was discussed in Terra's report, however, in most cases we feel the maximum depths of liquefaction for design purposes should be higher. Our maximum soil liquefaction depths are reflected in the in soil layers provided in the attached P-y curve data sheets.

The effects of soil liquefaction may range from embankment failures to settlement of the embankments and the abutments. All of the existing piers are supported by low to medium capacity piling. Some of the piling extends through the potentially liquefiable soil, while some does not. We understand that total retrofitting of all structures to mitigate this condition is not within the scope of this project. We feel, however, that the shafts installed for the widenings should be designed to avoid excessive lateral or vertical movement under seismic loading.

The main effect of soil liquefaction and associated settlement would be the generation of downdrag forces on the drilled shafts. Our recommended capacities are based on the effect of downdrag, with a safety factor of 1.5 against vertical plunging failure during seismic loading. This will require the end pier shafts to extend well below the estimated liquefaction depth. In the cases listed below, we recommend the shaft tips not be founded between certain elevations to avoid settlement of deeper loose layers. In general, the depths were chosen to provide at least two shaft diameters of denser soil above the loose soil.

| Bridge Number | Piers                          | Intermediate Shaft Tip Elevations at which Tips should not be founded |
|---------------|--------------------------------|---|
| 167/121       | End only<br>(Piers 1 & 4)      | -5' to -32'   |
| 167/123       | End only<br>(Piers 1 & 4)      | -10' to -28'  |
| 167/126       | End only<br>(Piers 1 & 4)      | 0' to -28'  |
| 167/127       | Interior only<br>(Piers 2 & 3) | 0' to -21'  |
| 167/128       | End only<br>(Piers 1 & 4)      | -5' to -26'   |

Final vertical and lateral shaft capacity requirements for Bridges 167/125 through 128, as well as well as for Bridges 167/121 through 124 sent to you previously are provided in the attached figures and tables. Note that both static and dynamic soil parameters are provided for P-Y curve generation, but that vertical shaft capacities are only provided for the dynamic case, based on direction from your office that the dynamic case will control shaft depth and vertical capacity.

Construction considerations and advisory specifications for the drilled shafts are not available at this time, but will be included in the final supplemental foundation report for this project.

M. M. Lwin/W. Whitney

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Should you or your staff have any additional questions related to this project, please contact Tony Allen at 586-7088 or Henry Gertje at 586-7838.

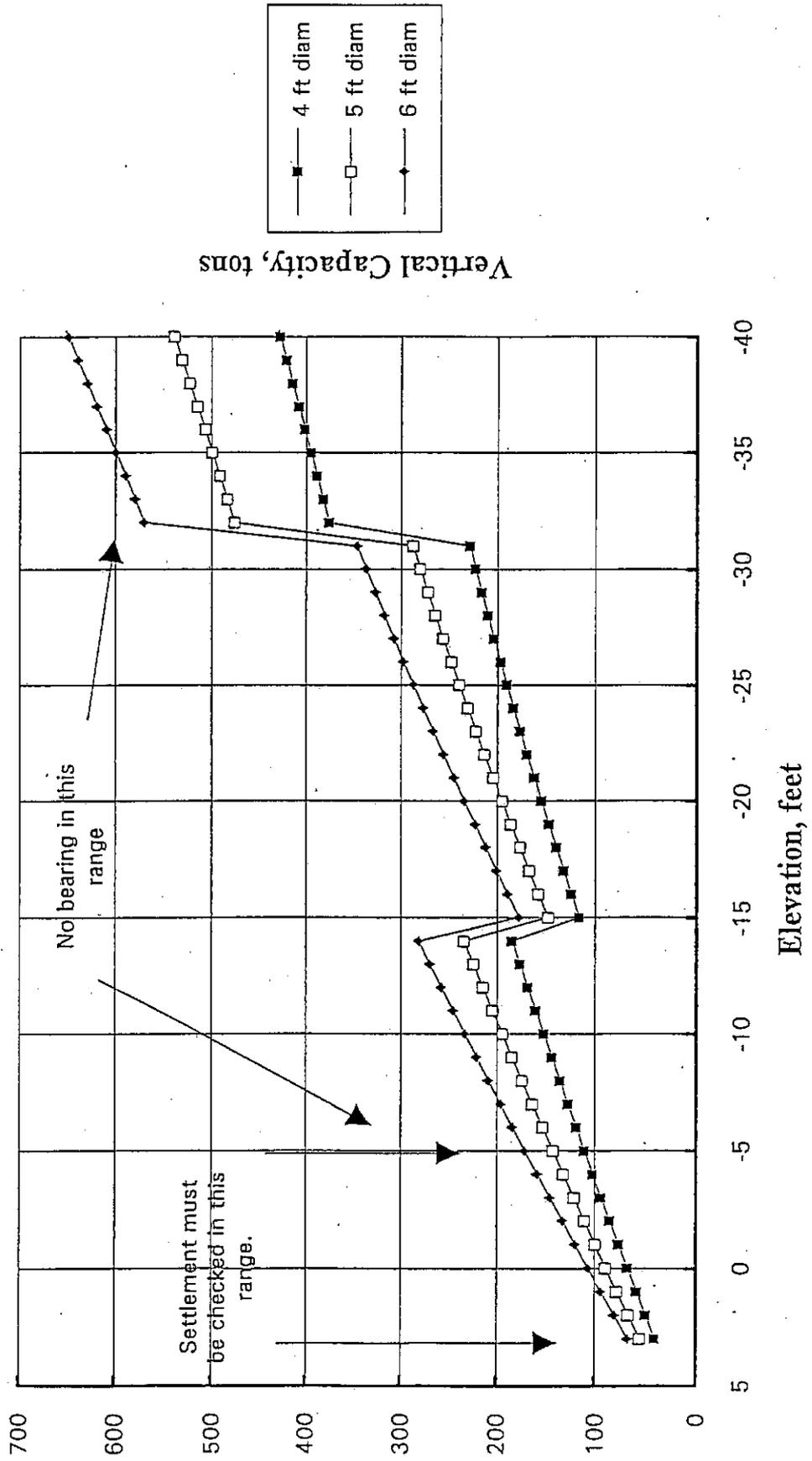
RGF:hg

HG

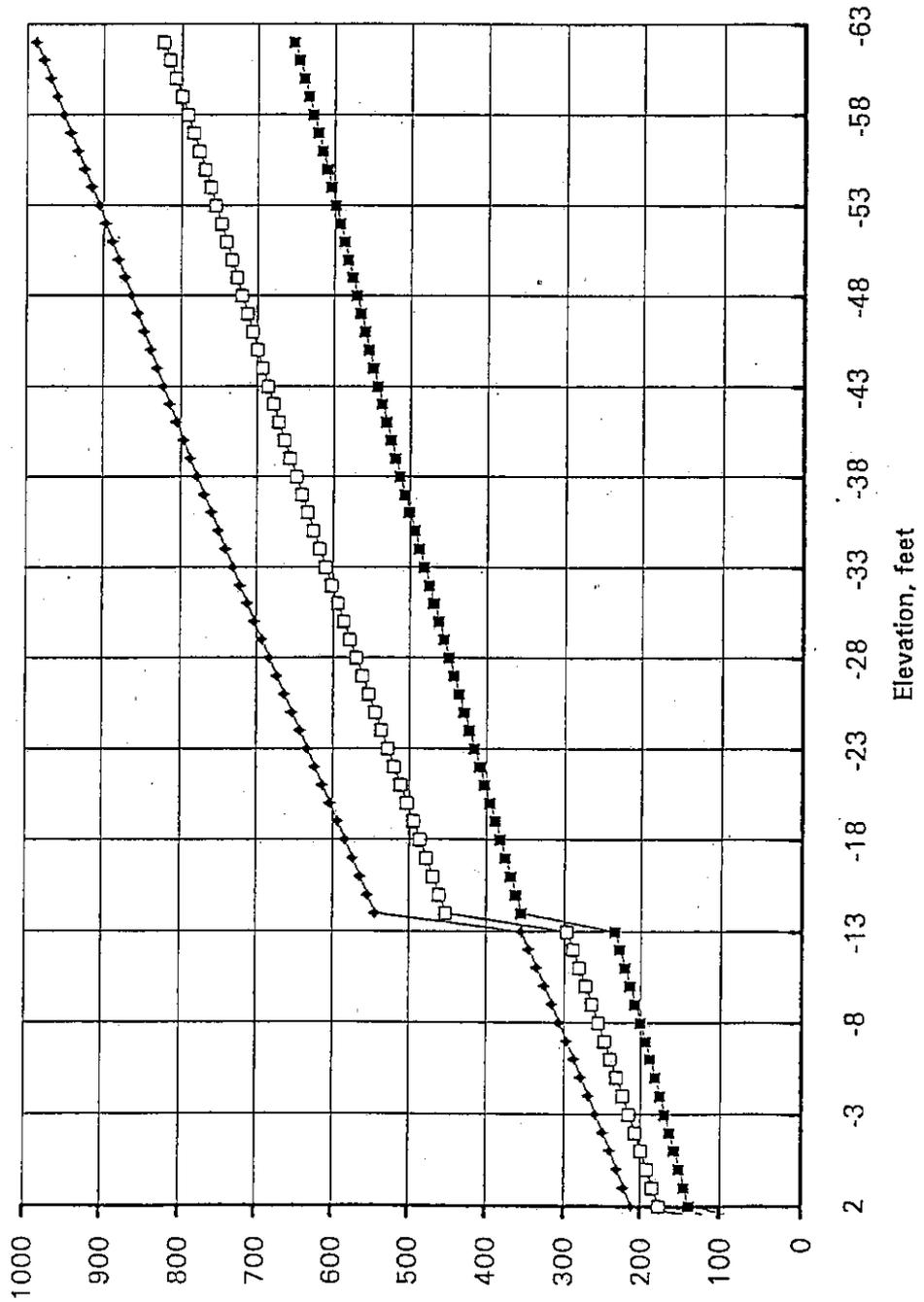
cc: D. Jackson, State Design Engineer, 7329  
J. Weigel, Acting Construction Engineer, 7354  
R. Mattila, Operations Engineer, D-1 NB82-114  
A. Stiles, Materials Engineer, D-1 NB82-29

**Design Requirements**  
**Br. 167/121**

# Br. 167/121 Green River Bridges Shaft Capacity vs. Elevation, End Piers



# Br. 167/121 SR-516 Overcrossing Bridges Shaft Capacity vs. Elevation, Interior Piers



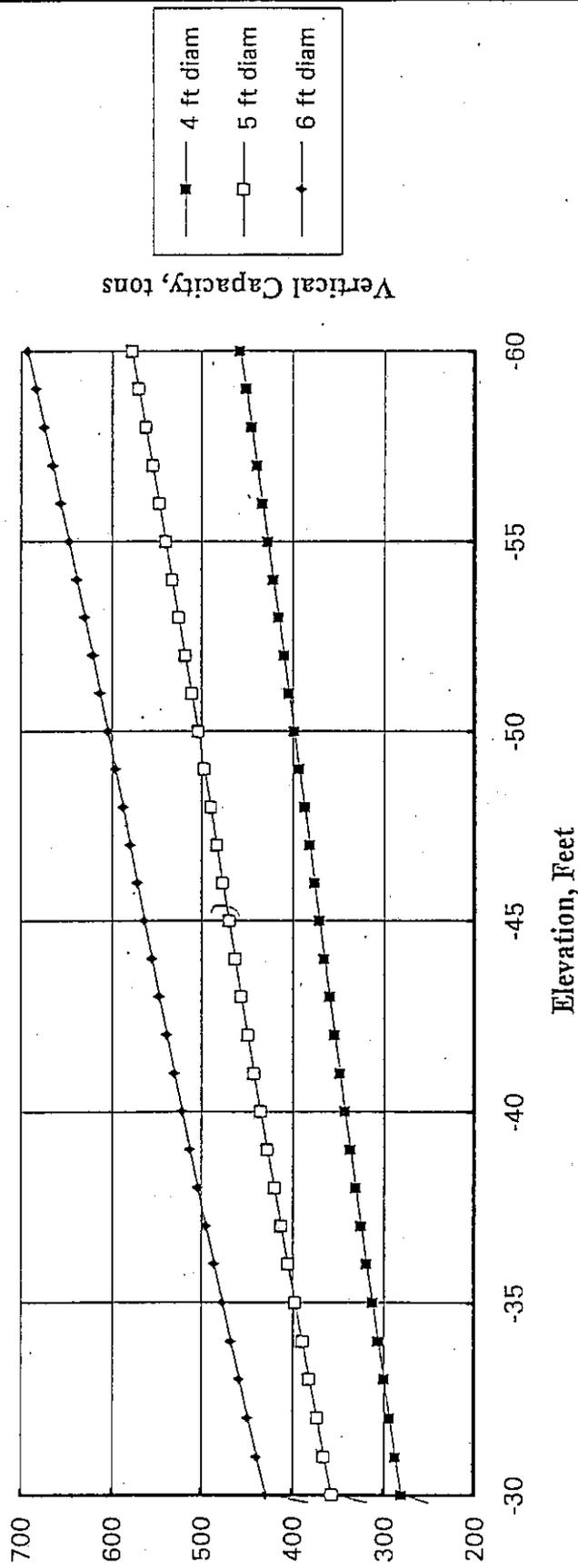
Elevation, feet

—■— 4 ft. diam

—◇— 5 ft. diam

—▲— 6 ft. diam

# Br. 167/121 Green River Bridges Shaft Capacity vs. Elevation, Interior Piers



**SR-167 15th ST to Grady Way  
Bridges No. 167/121 E&W Widen: Green River Bridges**

Py Curve Soil Data for COM-624

Applies to Piers: **END PIERS ONLY**

Reference Elevation: **54 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|-------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                     |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 10  | SAND      | 130                                 | 0              | NA               | 36                       | 160  | 36                       | 160  |
| 2          | 15  | SAND      | 115                                 | 0              | NA               | 32                       | 70   | 32                       | 70   |
| 3          | 35  | SAND      | 53                                  | 0              | NA               | 32                       | 50   | *                        | 5  |
| 4          | 68  | SAND      | 58                                  | 0              | NA               | 36                       | 95   | 36                       | 95   |
| 5          | 85  | SAND      | 53                                  | 0              | NA               | 32                       | 50   | 32                       | 50   |
| 6          | BOTTOM OF SHAFT   | SAND      | 58                                  | 0              | NA               | 37                       | 105  | 37                       | 105  |

\* For potentially liquefiable soil unit 3, model as a soft clay with cohesion = 200 psf and E50 = 2%

**SR-167 15th ST to Grady Way  
Bridges No. 167/121 E&W Widen: Green River Bridges**

**.Py Curve Soil Data for COM-624**

**Applies to Piers:** *INTERIOR PIERS ONLY*

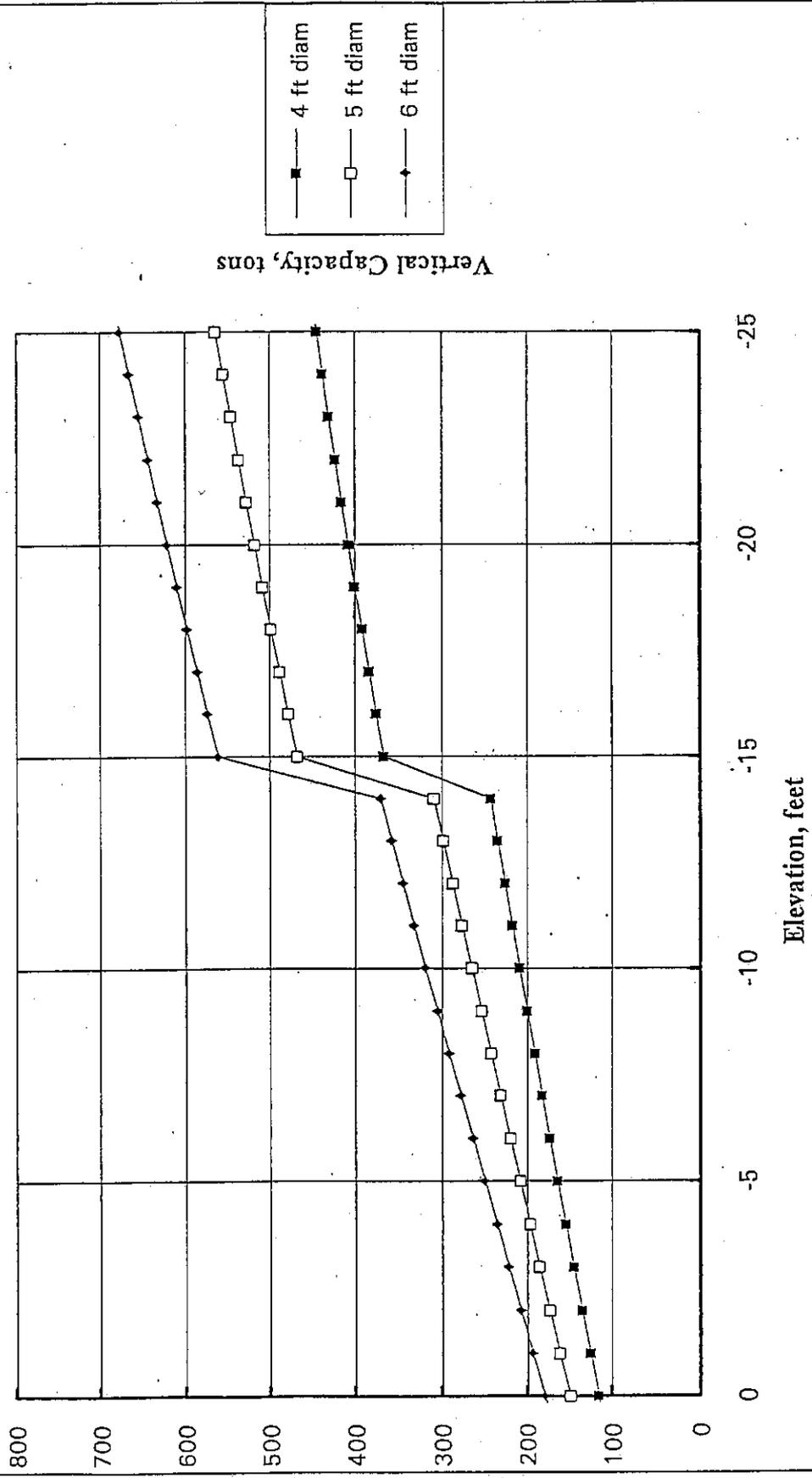
**Reference Elevation:** 40 FEET

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil, (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|--------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                      |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 20  | SAND      | 53                                   | 0              | NA               | 32                       | 50   | *                        | 5  |
| 2          | 53  | SAND      | 58                                   | 0              | NA               | 36                       | 95   | 36                       | 95   |
| 3          | 70  | SAND      | 53                                   | 0              | NA               | 32                       | 50   | 28                       | 50   |
| 4          | BOTTOM OF SHAFT   | SAND      | 58                                   | 0              | NA               | 37                       | 105  | 37                       | 105  |

\* For potentially liquefiable soil unit 1, model as a soft clay with cohesion = 200 psf and E50 = 2%

**Design Requirements**  
**Br. 167/122**

# Br. 167/122, SR-516 Bridges Shaft Capacity vs. Elevation, End Piers



**SR-167 15th ST to Grady Way  
Bridges No. 167/122 E&W Widen: SR-516 Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

**Applies to Piers:**                      *END PIERS ONLY*

**Reference Elevation:**                      60 FEET

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|-------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                     |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 25  | SAND      | 140                                 | 0              | NA               | 38                       | 200  | 36                       | 200  |
| 2          | 45  | SAND      | 48                                  | 0              | NA               | 32                       | 50   | *                        | 5  |
| 3          | 57  | SAND      | 53                                  | 0              | NA               | 32                       | 50   | 32                       | 50   |
| 4          | 74  | SAND      | 58                                  | 0              | NA               | 35                       | 80   | 35                       | 80   |
| 5          | BOTTOM OF SHAFT   | SAND      | 63                                  | 0              | NA               | 40                       | 130  | 40                       | 130  |

\* For potentially liquefiable soil unit 2, model as a soft clay with cohesion = 200 psf and E50 = 2%

**SR-167 15th ST to Grady Way  
Bridges No. 167/122 E&W Widen: SR-516 Overcrossing Bridges**

Py Curve Soil Data for COM-624

Applies to Piers: **INTERIOR PIERS ONLY**

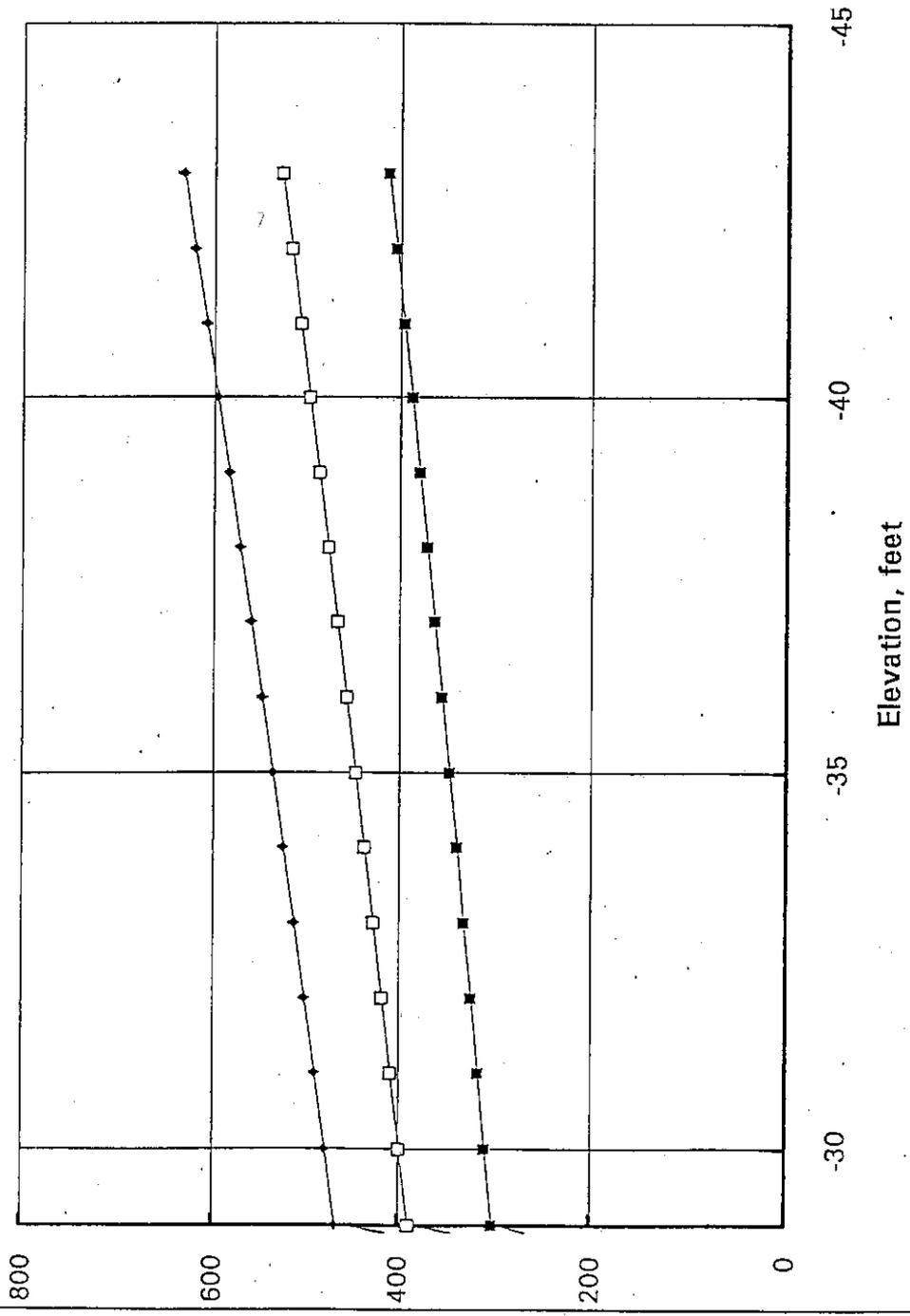
Reference Elevation: **38 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|-------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                     |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 3   | SAND      | 140                                 | 0              | NA               | 36                       | 160  | 38                       | 160  |
| 2          | 23  | SAND      | 48                                  | 0              | NA               | 32                       | 50   | *                        | 5  |
| 3          | 35  | SAND      | 53                                  | 0              | NA               | 32                       | 50   | 32                       | 10   |
| 4          | 52  | SAND      | 58                                  | 0              | NA               | 35                       | 80   | 35                       | 80   |
| 5          | BOTTOM OF SHAFT   | SAND      | 63                                  | 0              | NA               | 40                       | 130  | 40                       | 130  |

\* For potentially liquefiable soil unit 2, model as a soft clay with cohesion = 200 psf and E50 = 2%

**Design Requirements**  
**Br. 167/123**

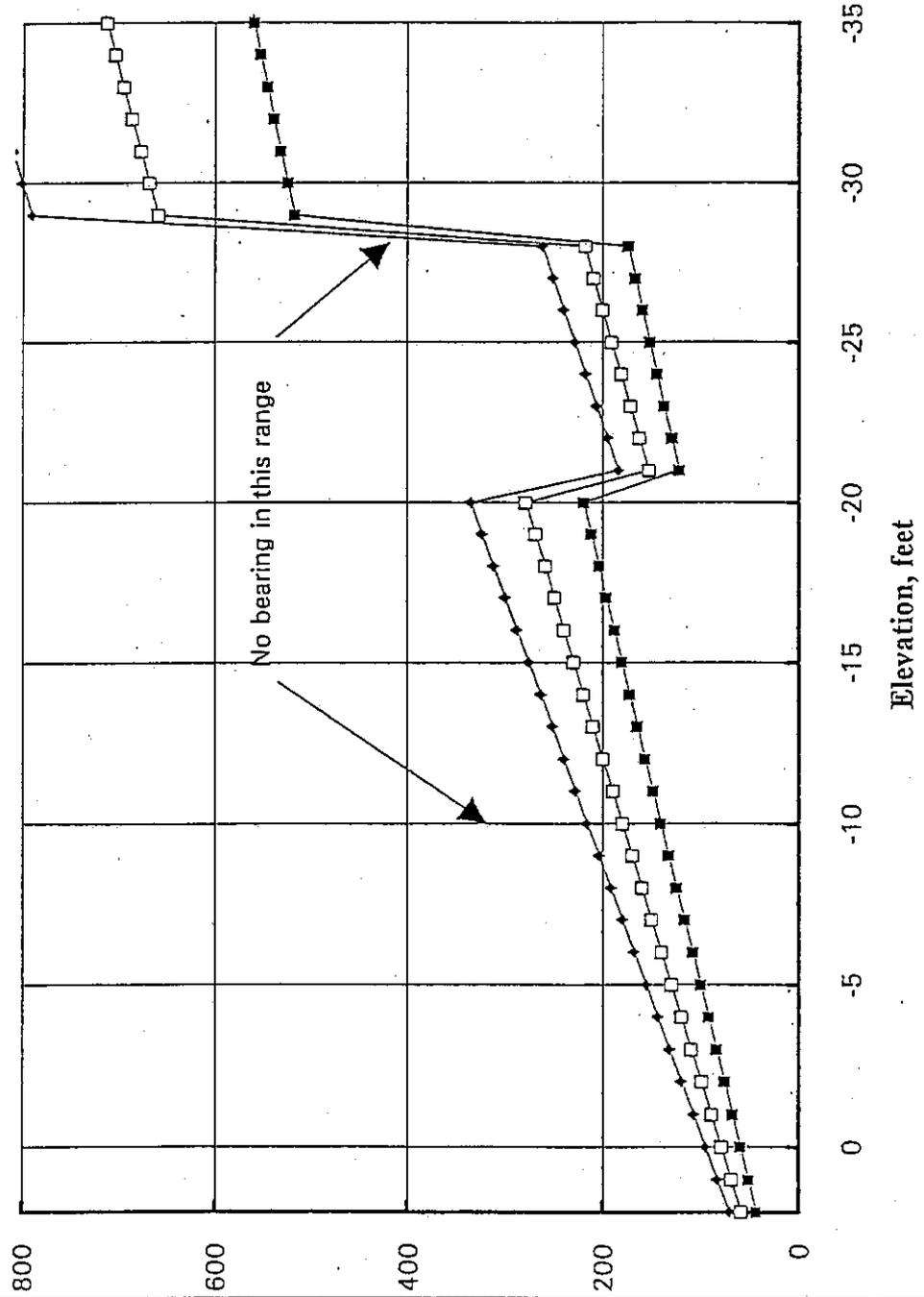
**Br. 167/23 Meeker Street Overcrossing Bridges  
Shaft Capacity vs. Elevation, Pier 1**



Vertical Capacity, tons

4 ft diam  
5 ft diam  
6 ft diam

# SR-167/123 Meeker Street Overcrossing Bridges Shaft Capacity vs. Elevation, Pier 2



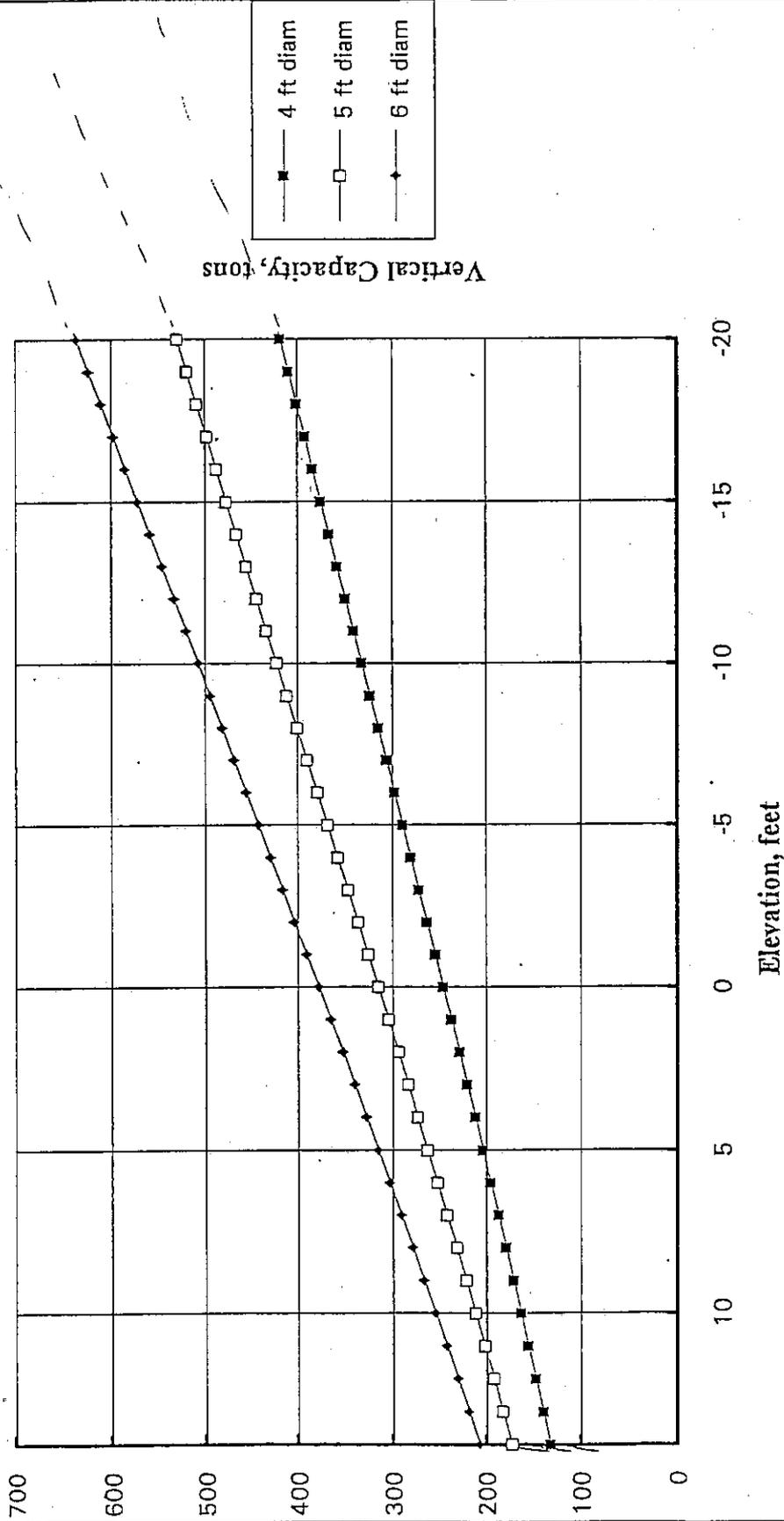
Vertical Capacity, ton

- 4 ft. diam.
- 5 ft. diam.
- ▲— 6 ft. diam.

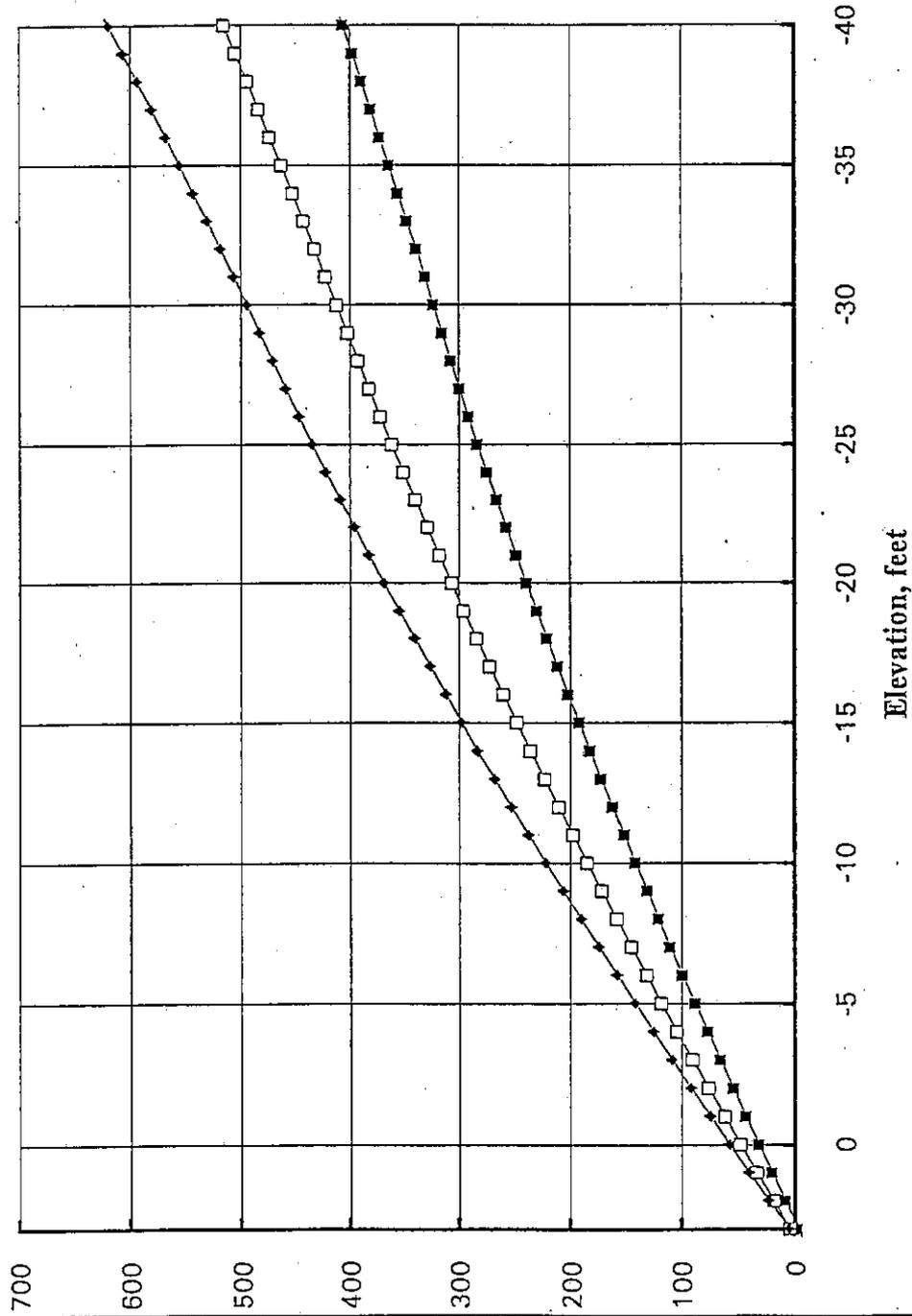
No bearing in this range

Elevation, feet

Br. 167/123, Meeker Street Overcrossing Bridges  
Shaft Capacity vs. Elevation  
Seismic Conditions, Pier 3



# Br. 167/123, Meeker Street Bridges Shaft Capacity vs. Elevation, Pier 4



Vertical Capacity, tons

4 ft diam  
5 ft diam  
6 ft diam

**SR-167 15th ST to Grady Way  
Bridges No. 167/123 E&W Widen: Meeker Street Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: **PIER 1**

Reference Elevation: **57 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|-------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                     |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 25  | SAND      | 140                                 | 0              | NA               | 40                       | 250  | 40                       | 250  |
| 2          | 32  | SAND      | 110                                 | 0              | NA               | 32                       | 70   | 32                       | 20   |
| 3          | 47  | SAND      | 48                                  | 0              | NA               | 32                       | 50   | *                        | 5  |
| 4          | 78  | SAND      | 53                                  | 0              | NA               | 35                       | 80   | 35                       | 80   |
| 5          | 86  | SAND      | 48                                  | 0              | NA               | 32                       | 50   | 32                       | 50   |
| 6          | BOTTOM OF SHAFT   | SAND      | 63                                  | 0              | NA               | 40                       | 140  | 40                       | 140  |

\* For potentially liquefiable soil unit 3, model as a soft clay with cohesion = 200 psf and E50 = 2%

**SR-167 15th ST to Grady Way  
Bridges No. 167/123 E&W Widen: Meeker Street Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: **PIER 2**

Reference Elevation: **38 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil, (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|--------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                      |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 6   | SAND      | 140                                  | 0              | NA               | 38                       | 200  | 38                       | 200  |
| 2          | 13  | SAND      | 110                                  | 0              | NA               | 32                       | 70   | 32                       | 20   |
| 3          | 28  | SAND      | 48                                   | 0              | NA               | 32                       | 50   | *                        | 5  |
| 4          | 58  | SAND      | 53                                   | 0              | NA               | 35                       | 80   | 35                       | 80   |
| 5          | 64  | SAND      | 48                                   | 0              | NA               | 32                       | 50   | 32                       | 50   |
| 6          | BOTTOM OF SHAFT   | SAND      | 63                                   | 0              | NA               | 40                       | 140  | 40                       | 140  |

\* For potentially liquefiable soil unit 3, model as a soft clay with cohesion = 200 psf and E50 = 2%

**SR-167 15th ST to Grady Way  
Bridges No. 167/123 E&W Widen: Mecker Street Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: **PIER 3**

Reference Elevation: **38 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil, (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|--------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                      |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 6   | SAND      | 140                                  | 0              | NA               | 38                       | 200  | 38                       | 200  |
| 2          | 13  | SAND      | 110                                  | 0              | NA               | 32                       | 70   | 32                       | 20   |
| 3          | 23  | SAND      | 48                                   | 0              | NA               | 32                       | 50   | *                        | 5  |
| 4          | BOTTOM OF SHAFT   | SAND      | 63                                   | 0              | NA               | 40                       | 140  | 40                       | 140  |

\* For potentially liquefiable soil unit 3, model as a soft clay with cohesion = 200 psf and E50 = 2%

**SR-167 15th ST to Grady Way  
Bridges No. 167/123 E&W Widen: Mecker Street Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: **PIER 4**

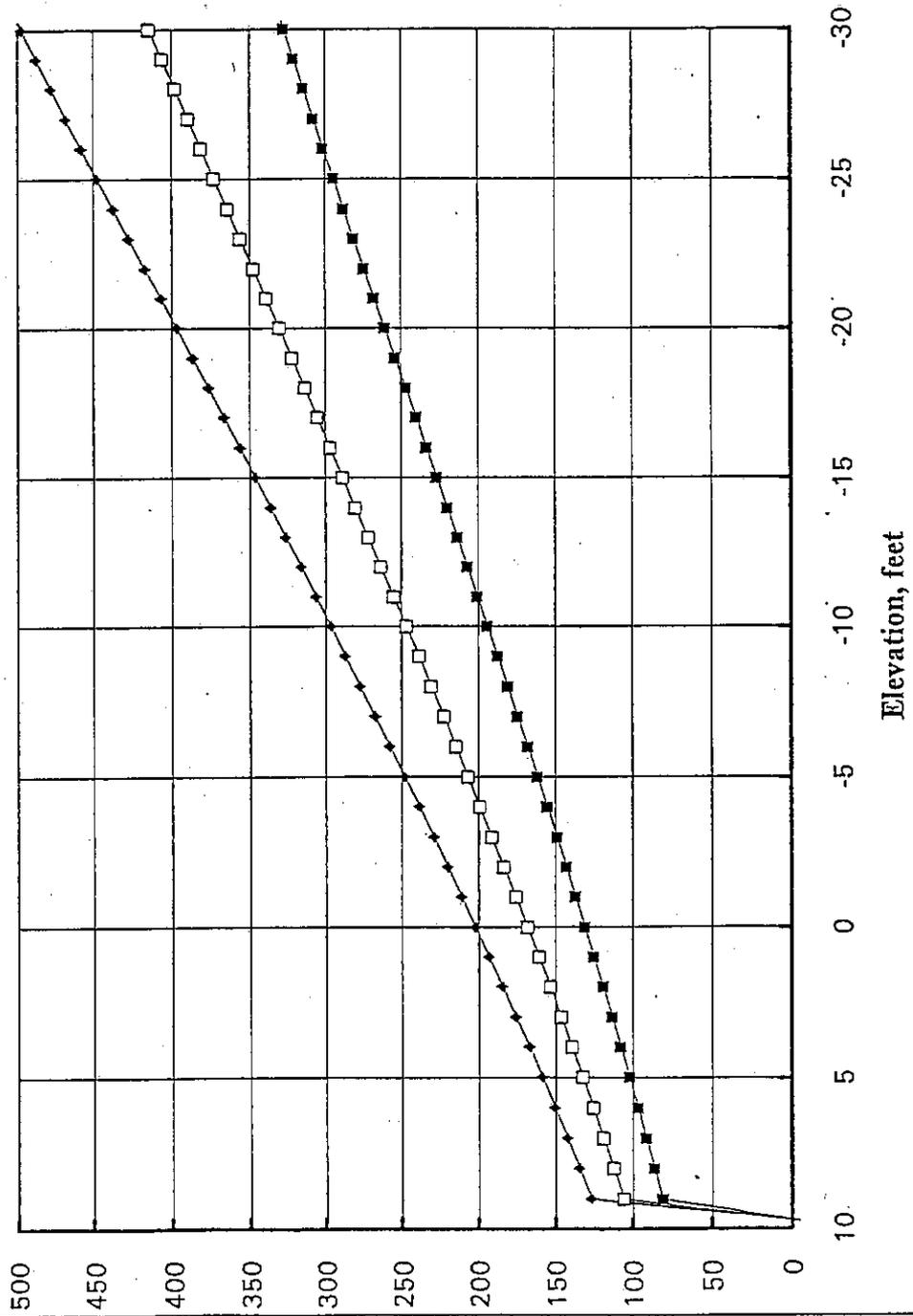
Reference Elevation: **57 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil, (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|--------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                      |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 25  | SAND      | 140                                  | 0              | NA               | 40                       | 250  | 40                       | 250  |
| 2          | 32  | SAND      | 110                                  | 0              | NA               | 32                       | 70   | 32                       | 20   |
| 3          | 42  | SAND      | 48                                   | 0              | NA               | 32                       | 50   | *                        | 5  |
| 4          | BOTTOM OF SHAFT   | SAND      | 63                                   | 0              | NA               | 40                       | 140  | 40                       | 140  |

\* For potentially liquefiable soil unit 3, model as a soft clay with cohesion = 200 psf and E50 = 2%

**Design Requirements**  
**Br. 167/124**

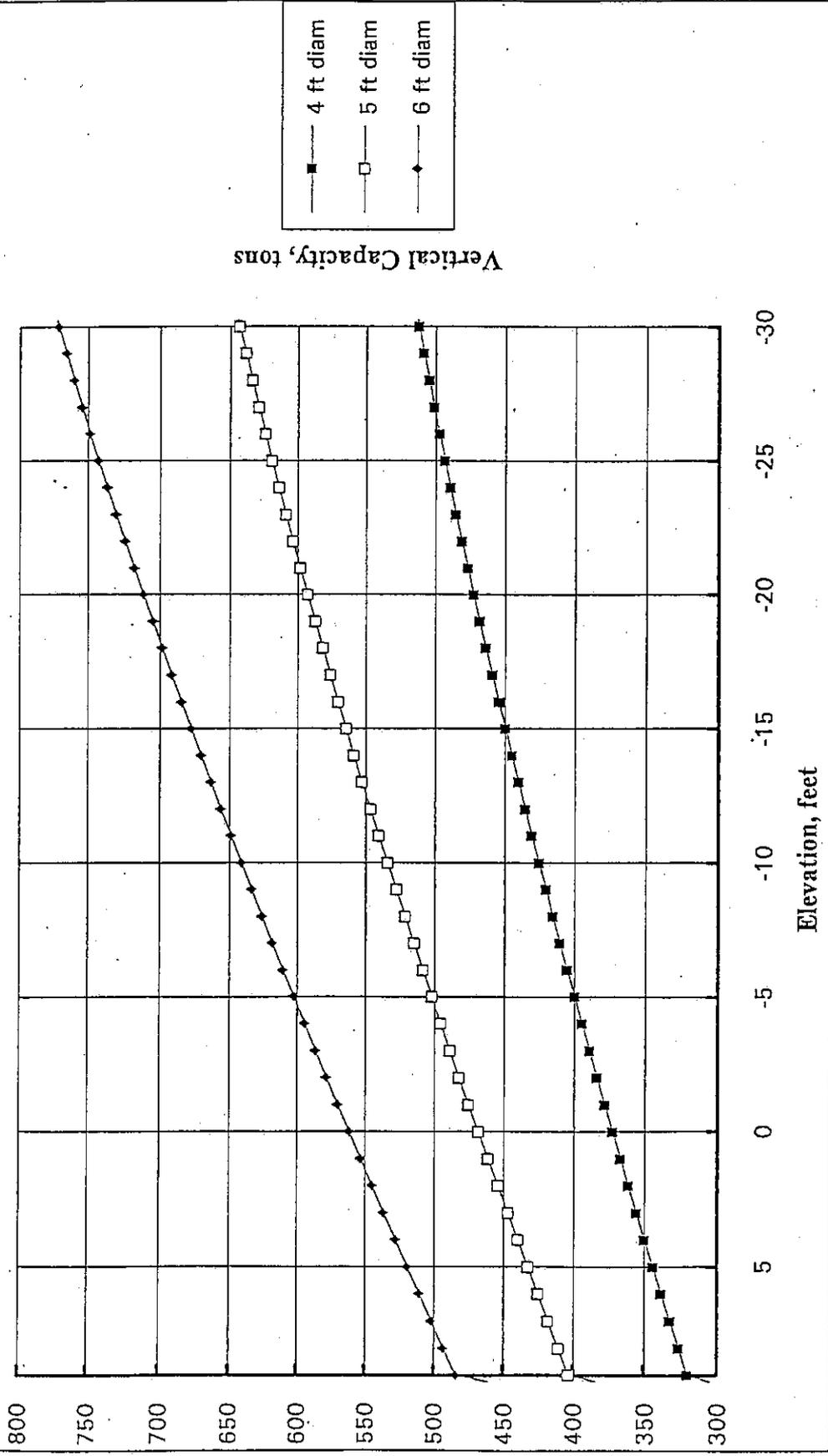
# Br. 167/124 James Street Overcrossing Bridges Shaft Capacity vs. Elevation, Interior Piers



Vertical Capacity, tons

4 ft diam  
5 ft diam  
6 ft diam

Br. 167/124, James Street Overcrossing Bridges  
 Shaft Capacity vs. Elevation, End Piers



Vertical Capacity, tons

4 ft diam  
 5 ft diam  
 6 ft diam

Elevation, feet

**SR-167 15th ST to Grady Way  
Bridges No. 167/124 E&W Widen: James Street Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: **END PIERS ONLY**

Reference Elevation: **54 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil, (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|--------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                      |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 28  | SAND      | 140                                  | 0              | NA               | 40                       | 250  | 40                       | 250  |
| 2          | 48  | SAND      | 48                                   | 0              | NA               | 32                       | 50   | 32                       | 20   |
| 3          | BOTTOM OF SHAFT   | SAND      | 58                                   | 0              | NA               | 36                       | 100  | 36                       | 100  |

**SR-167 15th ST to Grady Way  
Bridges No. 167/124 E&W Widen: James Street Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

**Applies to Piers:**      *INTERIOR PIERS ONLY*

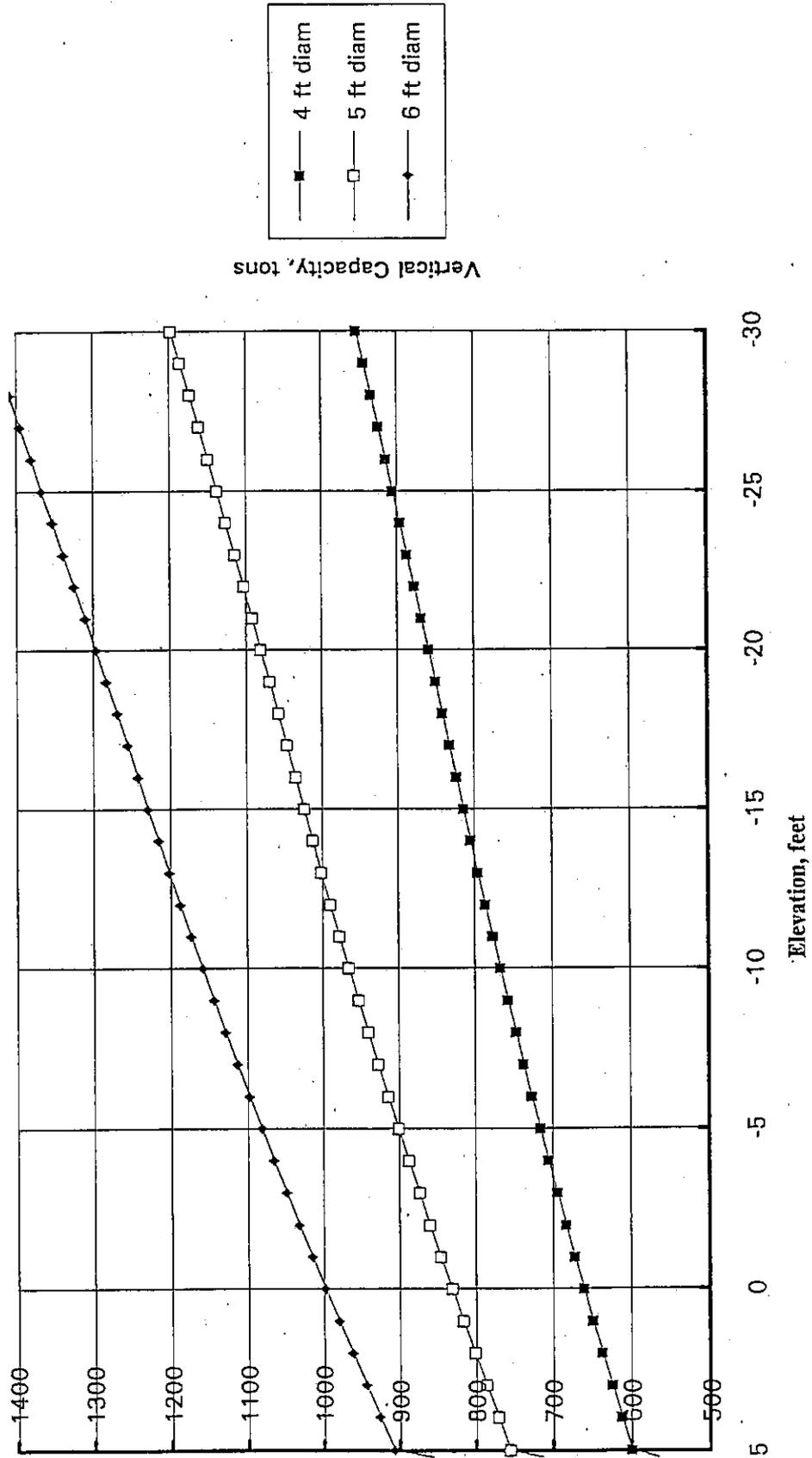
**Reference Elevation:**      33

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|-------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                     |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 3   | SAND      | 140                                 | 0              | NA               | 38                       | 250  | 38                       | 250  |
| 2          | 13  | SAND      | 48                                  | 0              | NA               | 32                       | 40   | *                        | 5  |
| 3          | BOTTOM OF SHAFT   | SAND      | 58                                  | 0              | NA               | 36                       | 100  | 36                       | 100  |

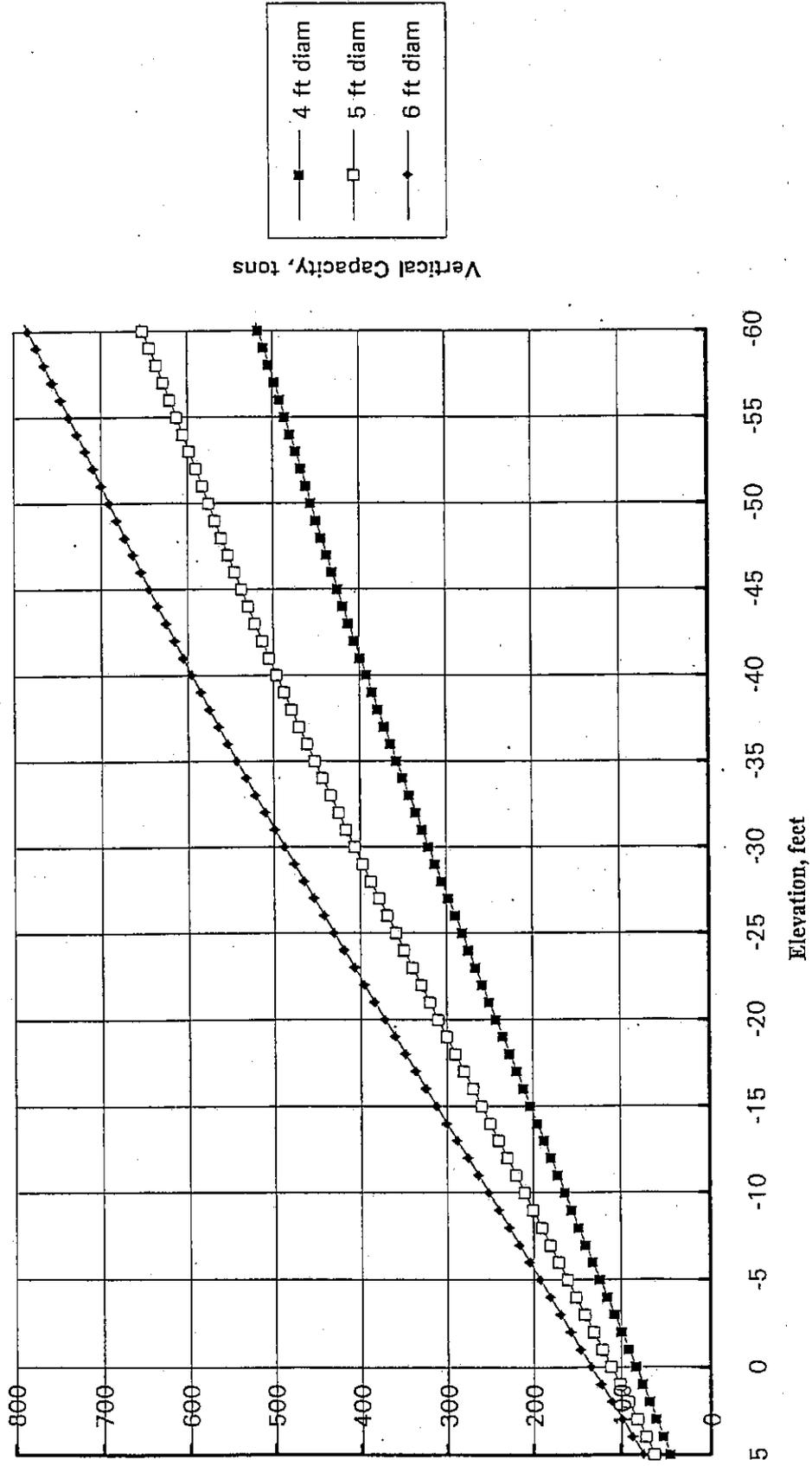
\* For potentially liquefiable soil unit 2, model as a soft clay with cohesion = 200 psf and E50 = 2%

**Design Requirements**  
**Br. 167/125**

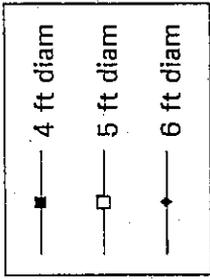
**Br. 167/125, UPRR Overcrossing**  
**Shaft Capacity vs. Elevation**  
**Seismic Conditions, End Piers**



**Br. 167/125, UPRR Overcrossing**  
**Shaft Capacity vs. Elevation**  
**Seismic Conditions, Interior Piers**



Vertical Capacity, tons



Elevation, feet

**SR-167 15th ST to Grady Way  
Bridges No. 167/125 E&W Widen: UPRR Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: *END PIERS ONLY*

Reference Elevation: 70 FEET

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil. (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|--------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                      |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 40  | SAND      | 140                                  | 0              | NA               | 38                       | 180  | 38                       | 180  |
| 2          | 64  | SAND      | 48                                   | 0              | NA               | 32                       | 50   | 32                       | 20   |
| 3          | BOTTOM OF SHAFT   | SAND      | 58                                   | 0              | NA               | 35                       | 80   | 35                       | 80   |

**SR-167 15th ST to Grady Way  
Bridges No. 167/125 E&W Widen: UPRR Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: *INTERIOR PIERS ONLY*

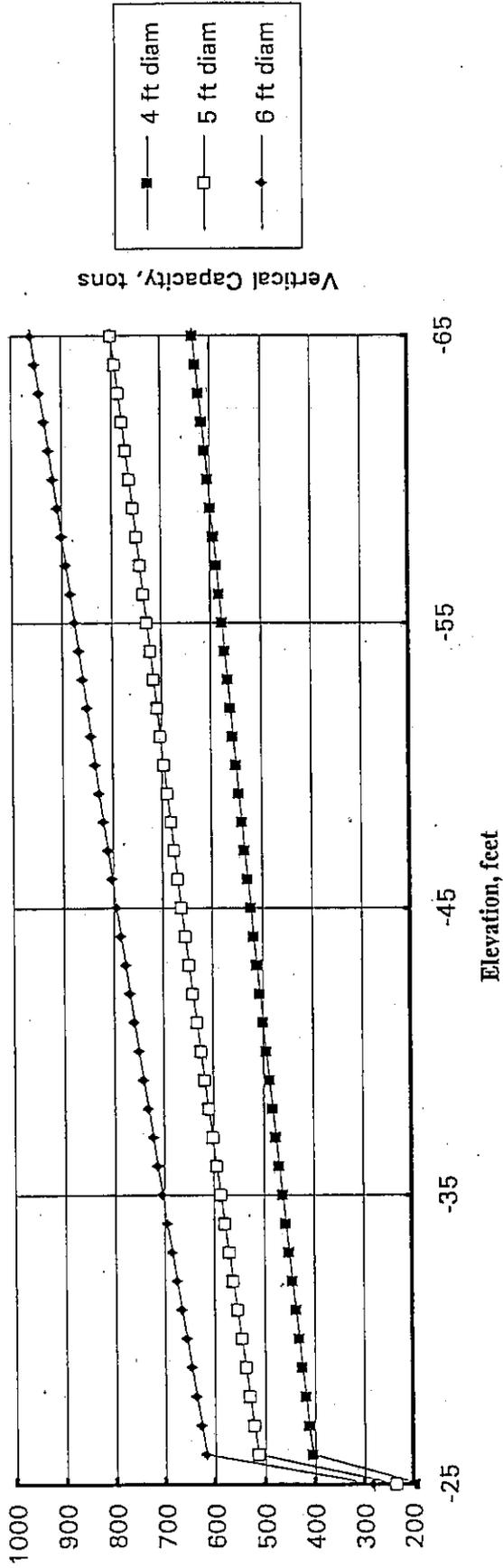
Reference Elevation: 35'

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil, (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|--------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                      |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 5   | SAND      | 140                                  | 0              | NA               | 38                       | 180  | 38                       | 180  |
| 2          | 29  | SAND      | 48                                   | 200*           | NA               | 32                       | 50   | 0                        | 5  |
| 3          | BOTTOM OF SHAFT   | SAND      | 58                                   | 0              | NA               | 35                       | 80   | 35                       | 80   |

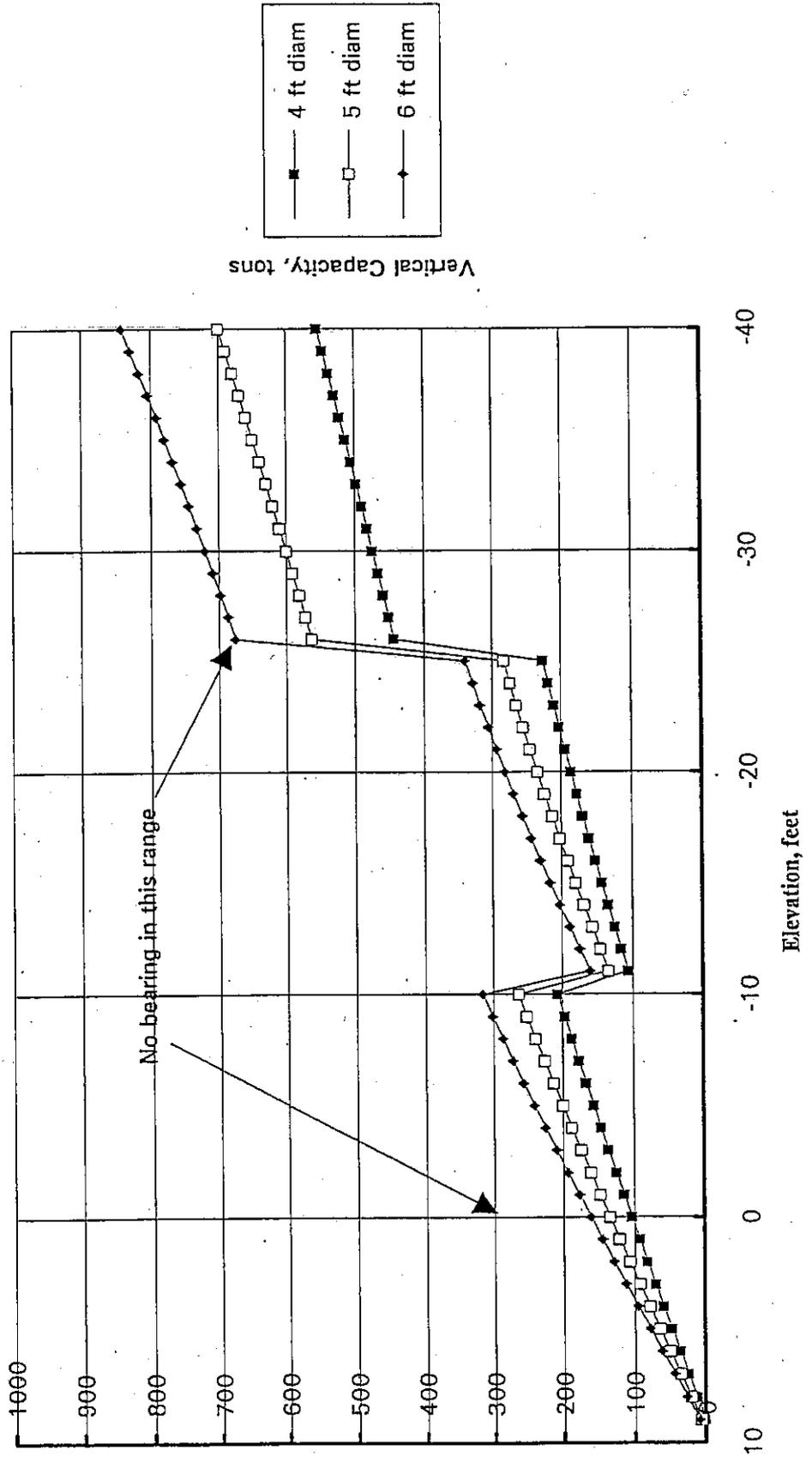
\* For potentially liquefiable soil unit 3, model as a soft clay with cohesion = 200 psf and E50 = 2%

**Design Requirements**  
**Br. 167/126**

Br. 167/126, 4th Ave. Overcrossing  
Shaft Capacity vs. Elevation  
Seismic Conditions, Interior Piers



### Br. 167/126, 4th Ave. Overcrossing Shaft Capacity vs. Elevation Seismic Conditions, End Piers



**SR-167 15th ST to Grady Way  
Bridges No. 167/126 E&W Widen: 4th Avenue Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: **INTERIOR PIERS ONLY**

Reference Elevation: **34 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|-------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                     |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 5   | SAND      | 140                                 | 0              | NA               | 38                       | 160  | 38                       | 160  |
| 2          | 25  | SAND      | 48                                  | 0              | NA               | 32                       | 50   | *                        | 5  |
| 3          | 45  | SAND      | 58                                  | 0              | NA               | 34                       | 70   | 34                       | 40   |
| 4          | 66  | SAND      | 53                                  | 0              | NA               | 32                       | 50   | 32                       | 50   |
| 5          | BOTTOM OF SHAFT   | SAND      | 63                                  | 0              | NA               | 38                       | 100  | 38                       | 100  |

\* For potentially liquefiable soil unit 2, model as a soft clay with cohesion = 200 psf and E50 = 2%

**SR-167 15th ST to Grady Way  
Bridges No. 167/126 E&W Widen: 4th Avenue Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: **END PIERS ONLY**

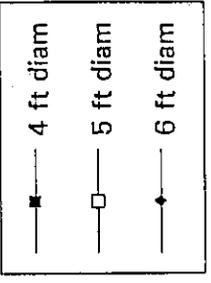
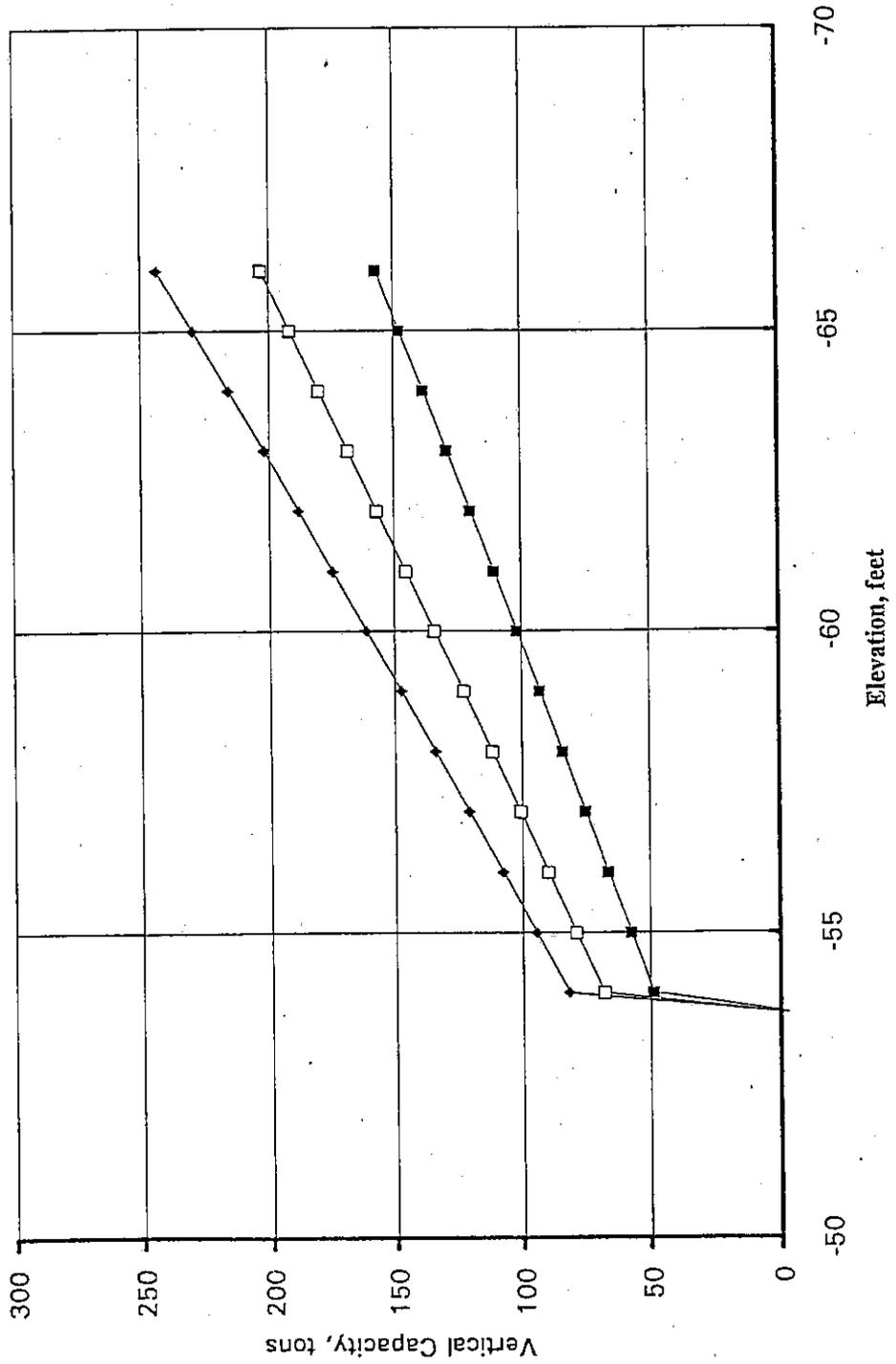
Reference Elevation: **60 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|-------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                     |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 30  | SAND      | 140                                 | 0              | NA               | 38                       | 160  | 38                       | 160  |
| 2          | 50  | SAND      | 48                                  | 0              | NA               | 32                       | 50   | *                        | 5  |
| 3          | 70  | SAND      | 58                                  | 0              | NA               | 34                       | 70   | 34                       | 40   |
| 4          | 85  | SAND      | 53                                  | 0              | NA               | 32                       | 50   | 32                       | 50   |
| 5          | BOTTOM OF SHAFT   | SAND      | 63                                  | 0              | NA               | 38                       | 100  | 38                       | 100  |

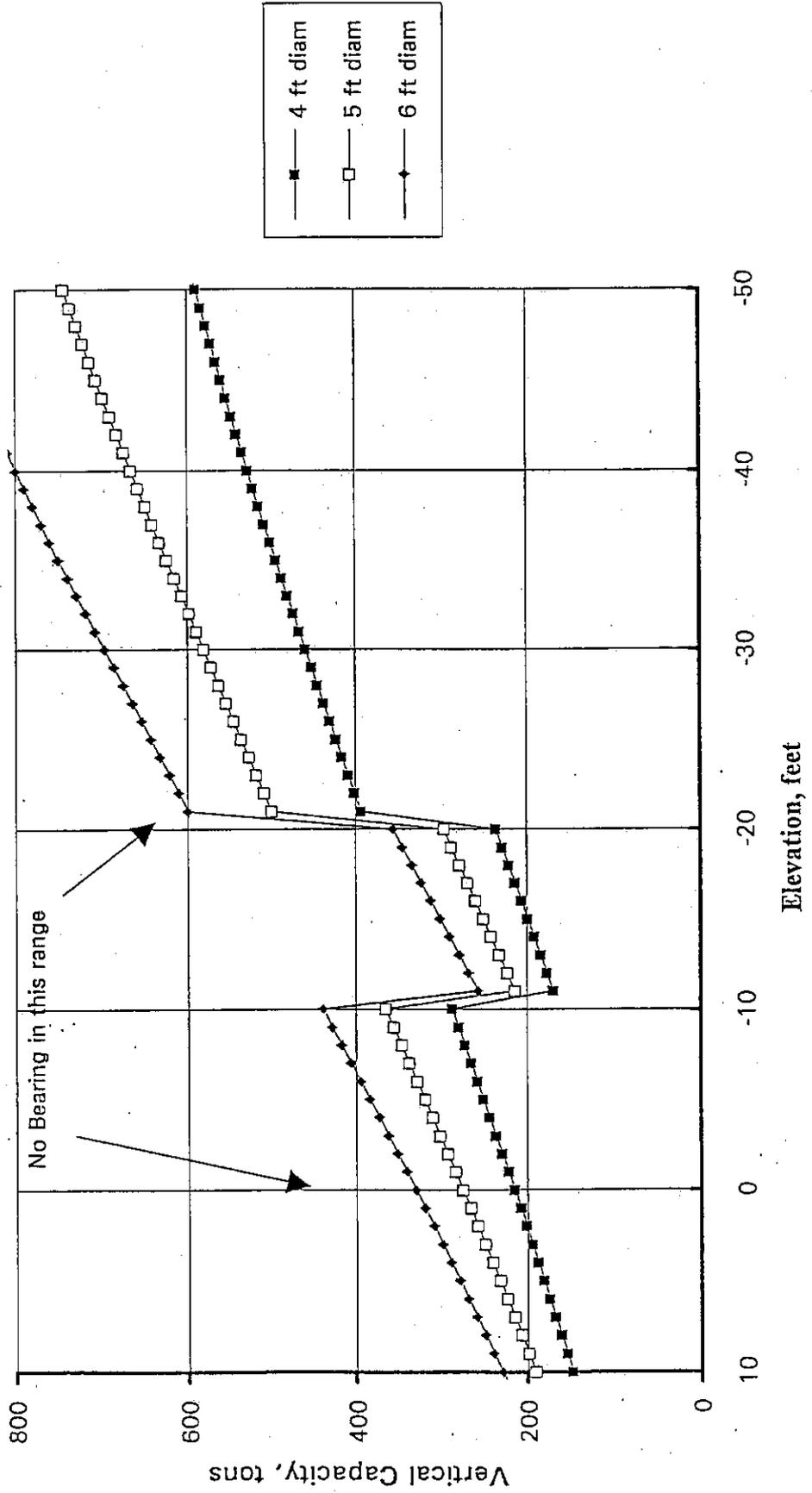
\* For potentially liquefiable soil unit 2, model as a soft clay with cohesion = 200 psf and E50 = 2%

**Design Requirements**  
**Br. 167/127**

**Br. 167/127, BNRR Overcrossing**  
**Shaft Capacity vs. Elevation**  
**Seismic Conditions, End Piers**



### Br. 167/127, BNRR Overcrossing Shaft Capacity vs. Elevation Seismic Conditions, Interior Piers



**SR-167 15th ST to Grady Way  
Bridges No. 167/127 E&W Widen: BNRR Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: **INTERIOR PIERS ONLY**

Reference Elevation: **35 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil, (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|--------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                      |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 5   | SAND      | 140                                  | 0              | NA               | 38                       | 160  | 38                       | 160  |
| 2          | 20  | SAND      | 48                                   | 0              | NA               | 32                       | 50   | *                        | 5  |
| 3          | 45  | SAND      | 58                                   | 0              | NA               | 36                       | 100  | 36                       | 100  |
| 4          | 55  | SAND      | 53                                   | 0              | NA               | 34                       | 70   | 34                       | 70   |
| 5          | BOTTOM OF SHAFT   | SAND      | 63                                   | 0              | NA               | 38                       | 100  | 38                       | 100  |

\* For potentially liquefiable soil unit 2, model as a soft clay with cohesion = 200 psf and E50 = 2%

**SR-167 15th ST to Grady Way  
Bridges No. 167/127 E&W Widen: BNRR Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: **END PIERS ONLY**

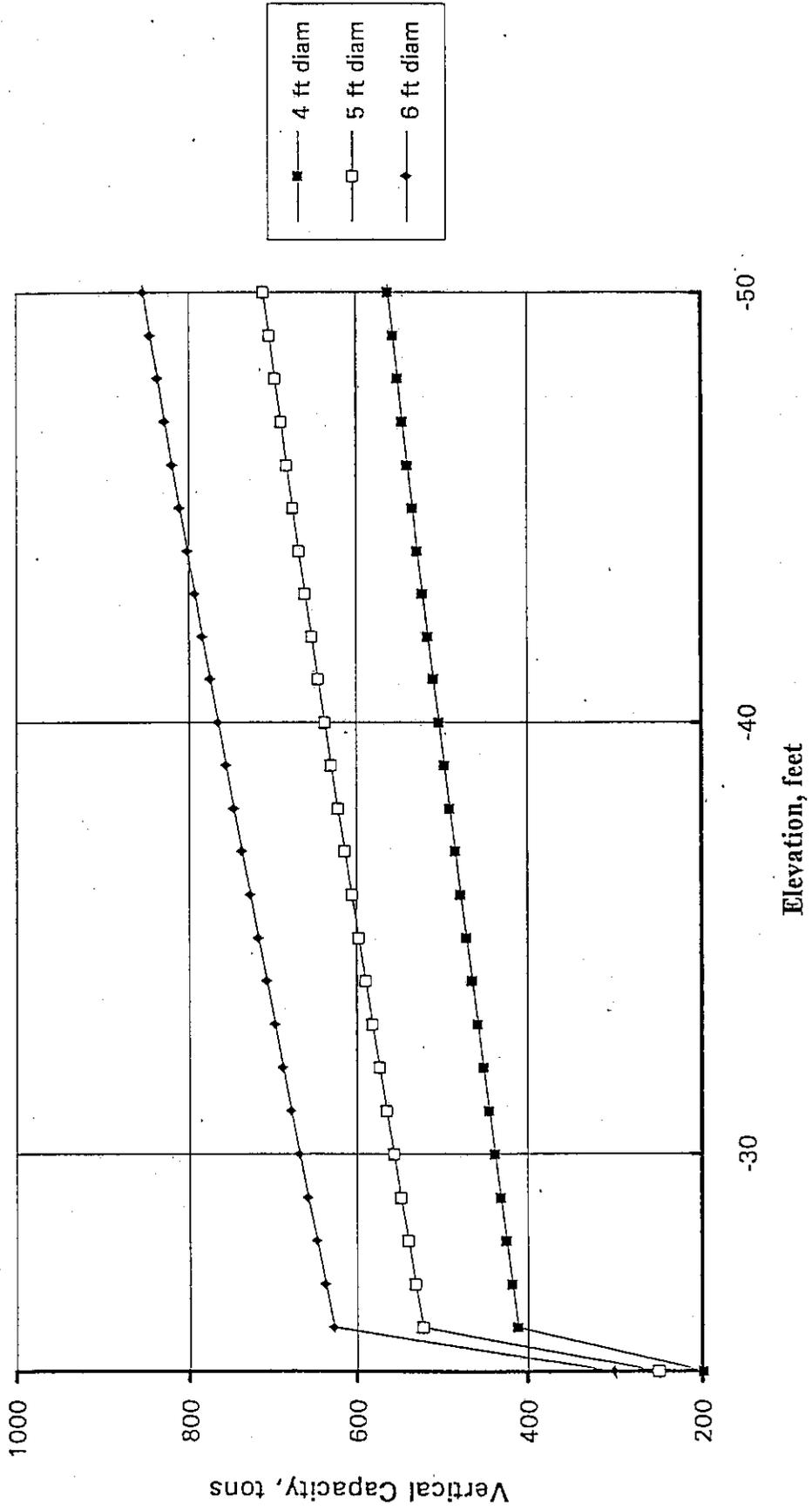
Reference Elevation: **67 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil. (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|--------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                      |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 37  | SAND      | 140                                  | 0              | NA               | 38                       | 160  | 38                       | 160  |
| 2          | 52  | SAND      | 48                                   | 0              | NA               | 32                       | 50   | *                        | 5  |
| 3          | 77  | SAND      | 58                                   | 0              | NA               | 36                       | 100  | 36                       | 100  |
| 4          | 87  | SAND      | 53                                   | 0              | NA               | 34                       | 70   | 34                       | 70   |
| 5          | BOTTOM OF SHAFT   | SAND      | 63                                   | 0              | NA               | 38                       | 100  | 38                       | 100  |

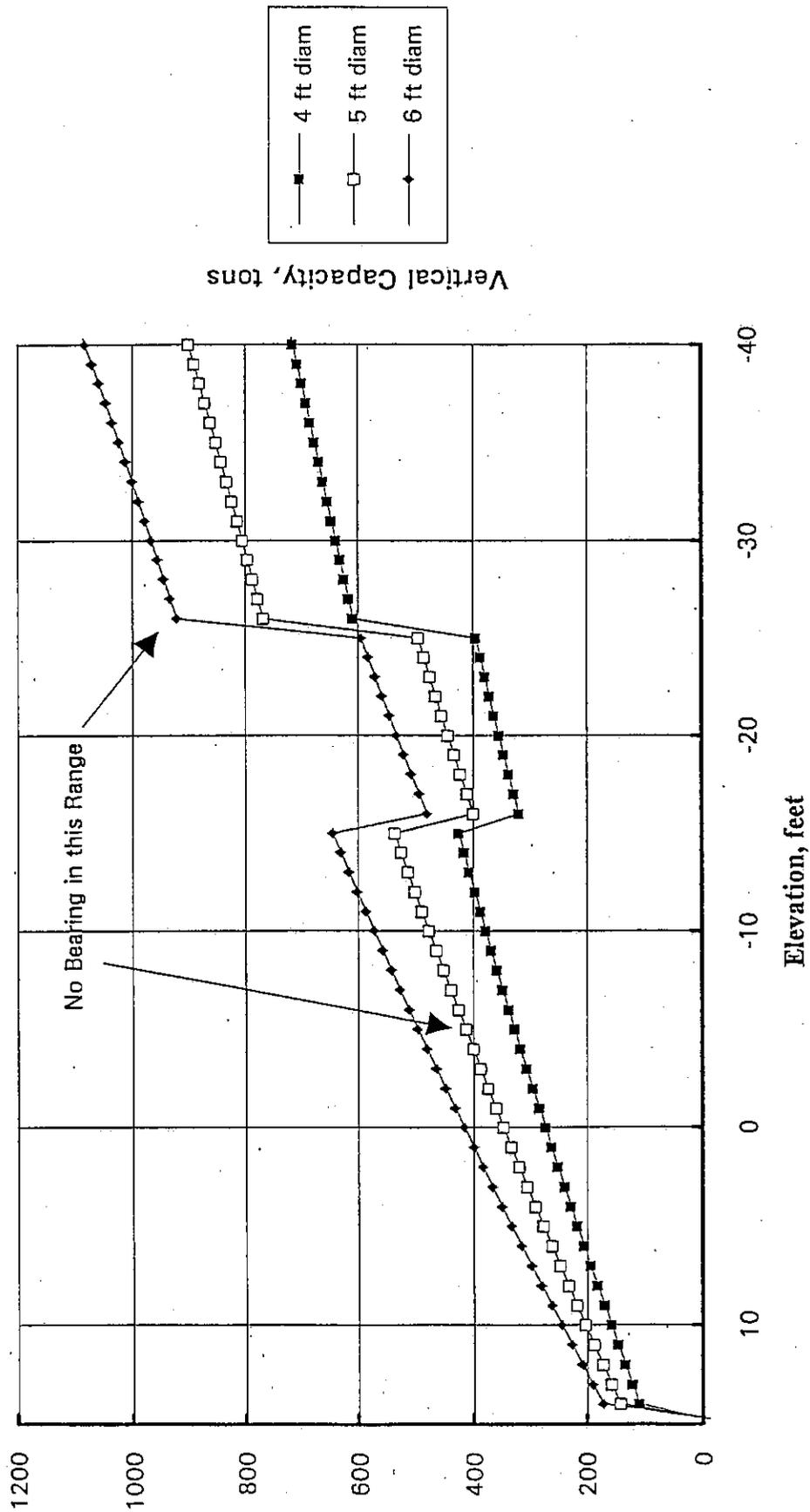
\* For potentially liquefiable soil unit 2, model as a soft clay with cohesion = 200 psf and E50 = 2%

**Design Requirements**  
**Br. 167/128**

**Br. 167/128, 84th Ave. Overcrossing**  
**Shaft Capacity vs. Elevation**  
**Seismic Conditions, Interior Piers**

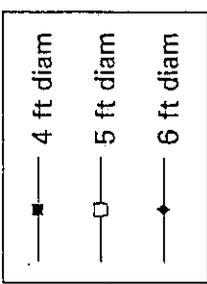


**Br. 167/128, 84th Ave. Overcrossing  
Shaft Capacity vs. Elevation  
Seismic Conditions, End Piers**



Vertical Capacity, tons

Elevation, feet



**SR-167 15th ST to Grady Way  
Bridges No. 167/128 E&W Widen: 84th Avenue Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

Applies to Piers: **INTERIOR PIERS ONLY**

Reference Elevation: **57 FEET**

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|-------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                     |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 29  | SAND      | 140                                 | 0              | NA               | 38                       | 160  | 38                       | 160  |
| 2          | 42  | SAND      | 48                                  | 0              | NA               | 28                       | 20   | *                        | 5  |
| 3          | 72  | SAND      | 53                                  | 0              | NA               | 35                       | 80   | 35                       | 80   |
| 4          | 82  | SAND      | 48                                  | 0              | NA               | 32                       | 50   | 32                       | 50   |
| 5          | BOTTOM OF SHAFT   | SAND      | 63                                  | 0              | NA               | 38                       | 100  | 38                       | 100  |

\* For potentially liquefiable soil unit 2, model as a soft clay with cohesion = 200 psf and E50 = 2%

**SR-167 15th ST to Grady Way  
Bridges No. 167/128 E&W Widen: 84th Avenue Overcrossing Bridges**

**Py Curve Soil Data for COM-624**

*INTERIOR PIERS ONLY*

Applies to Piers:

Reference Elevation: 34 FEET

| Soil Layer | Depth Below Reference Elevation to Bottom of Layer (feet) | Soil Type | Effective Unit Weight of Soil (pcf) | Cohesion (psf) | Axial Strain E50 | STATIC ANALYSIS          |  | DYNAMIC ANALYSIS         |  |
|------------|---|-----------|-------------------------------------|----------------|------------------|--------------------------|--|--------------------------|--|
|            |   |           |                                     |                |                  | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) | Friction Angle (degrees) | Modulus of Subgrade Reaction (lb/in <sup>3</sup> ) |
| 1          | 6   | SAND      | 140                                 | 0              | NA               | 38                       | 160  | 38                       | 160  |
| 2          | 19  | SAND      | 48                                  | 0              | NA               | 28                       | 20   | *                        | 5  |
| 3          | 49  | SAND      | 53                                  | 0              | NA               | 35                       | 80   | 35                       | 80   |
| 4          | 59  | SAND      | 48                                  | 0              | NA               | 32                       | 50   | 32                       | 50   |
| 5          | BOTTOM OF SHAFT   | SAND      | 63                                  | 0              | NA               | 38                       | 100  | 38                       | 100  |

\* For potentially liquefiable soil unit 2, model as a soft clay with cohesion = 200 psf and E50 = 2%